REPORT OF THE PANEL ON COMPOSITION & NUTRITIVE VALUE OF FLOUR

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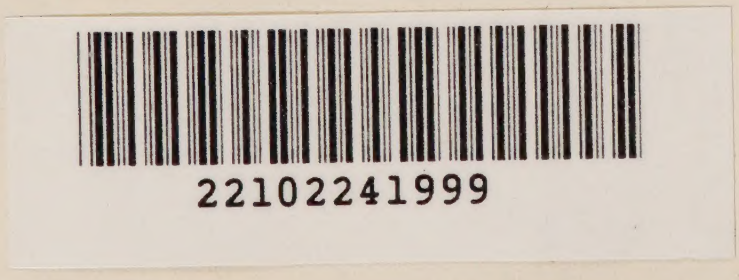

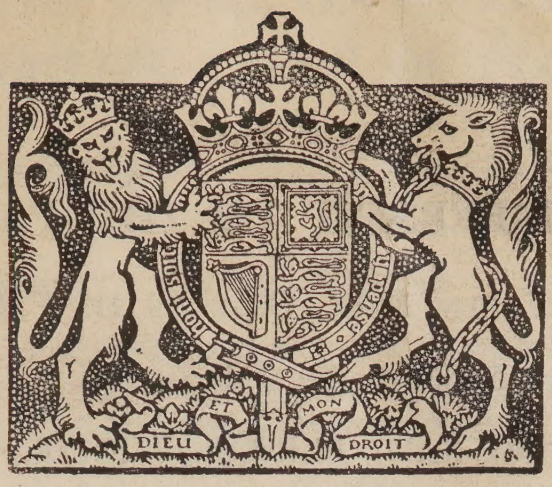

Report of the Panel on Composition and Nutritive Value of Flour

Presented to Parliament by the Secretary of State for Scotland, the Minister of Agriculture, Fisheries and Food and the Minister of Health by Command of Her Majesty
May 1956

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REPORT OF THE PANEL ON COMPOSITION AND NUTRITIVE VALUE OF FLOUR

To the Right Honourable JAMES STUART, M.V.O., M.C., M.P.,
Secretary of State for Scotland.

DEAR SECRETARY OF STATE,

I have the honour to submit to you and to your colleagues, the Minister of Agriculture, Fisheries and Food and the Minister of Health, the Report, which is unanimous, of the *Panel on Composition and Nutritive Value of Flour* which was appointed in May, 1955.

Since time was needed by many interested parties to prepare their evidence, both written and oral, the major work of the Committee has occupied less than four months. This would not have been possible without the unstinted help of our Secretary, Miss B. M. Shedden, and our Technical Secretary, Dr. K. Bryce Jones. To both, the Panel expresses its warm and sincere thanks.

I am sending copies of this Report to the Minister of Agriculture, Fisheries and Food and to the Minister of Health.

Yours sincerely,

(Sgd.) HENRY COHEN,
Chairman.
On behalf of the Panel.

10*th January*, 1956.

Letters in similar terms were sent simultaneously to

The Right Honourable DERICK HEATHCOAT AMORY, M.P.,
Minister of Agriculture, Fisheries and Food, and

The Right Honourable Major R. H. TURTON, M.C., M.P.,
Minister of Health.

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SECTION 1

APPOINTMENT AND TERMS OF REFERENCE

1.1. The Panel was appointed in May, 1955, by the Secretary of State for Scotland, the Minister of Agriculture, Fisheries and Food and the Minister of Health to make an independent authoritative review of the scientific and medical evidence now available on the differences in composition and nutritive value of flour of varying extraction rates. The Members of the Panel were nominated at the request of the Minister of Agriculture, Fisheries and Food by the President of the Royal Society (Lord Adrian, O.M.), and the Terms of Reference were—

"In the light of the scientific and medical evidence now available—

(1) to determine the differences in composition and nutritive value between

(*a*) National flour as defined in the Flour Order, 1953;

(*b*) flour of extraction rates less than National flour as defined in the Flour Order, 1953, to which the three token nutrients have been restored;

(*c*) flour of extraction rates less than National flour as defined in the Flour Order, 1953, to which the three token nutrients have not been restored; and

(2) to advise

whether any such differences are significant from the point of view of the health of the population."

SECTION 2

COMPOSITION OF THE PANEL

2.1. The composition of the Panel has been as follows:—

Professor Sir Henry Cohen, M.D., D.Sc., LL.D., F.R.C.P., J.P. (*Chairman*).

A. C. Chibnall, Esq., Ph.D., Sc.D., F.R.S.

Professor J. H. Gaddum, Sc.D., M.R.C.S., L.R.C.P., F.R.S.

Professor R. A. Morton, Ph.D., D.Sc., F.R.I.C., F.R.S.

Professor L. J. Witts, D.M., Sc.D., F.R.C.P.

SECTION 3

CONDUCT OF THE INQUIRY

3.1. At the outset of their inquiry the Panel was provided by the medical and scientific advisers to Government Departments with a brief statement of the background of their Terms of Reference, including a review of the main sources of medical and scientific evidence, and the relevant Official Reports and Statutory Instruments.

3.2. Having considered this background document the Panel decided to invite written evidence from all interests concerned with their Terms of Reference, and to ask representatives of the main organisations with responsibilities in this field to give oral evidence before them.

3.3. In addition, a Press Notice was issued drawing attention to the appointment of the Panel and inviting any organisation or member of the public who was interested in the Panel's problem to submit written evidence to the Secretary.

Section 4

SOURCES OF EVIDENCE

4.1. Written evidence has been received from the following:—

The Baking Industry of the United Kingdom:—

The British Baking Industries Research Association.
The British Cake and Biscuit Association.
The Cake and Biscuit Alliance, Ltd.
The Co-operative Bakery Trade Association.
The Federation of Wholesale and Multiple Bakers.
The Irish Association of Master Bakers.
The National Association of Master Bakers, Confectioners and Caterers.
The National Association of Biscuit Manufacturers.
The Scottish Association of Master Bakers.
The Wafer Biscuit Association, Ltd.

Mrs. Margaret Brady, M.Sc. (Mother and Child Advice Department, "Health for All" Magazine).
The British Medical Association.
The Department of Health for Scotland.
Mrs. Doris Grant.
Dr. W. I. M. Holman, Ph.D., F.R.I.C.
Dr. D. W. Kent-Jones, Ph.D., B.Sc., F.R.I.C.
Professor R. A. McCance, C.B.E., F.R.C.P., F.R.S.
The Medical Research Council.
The Ministry of Agriculture, Fisheries and Food.
The Ministry of Health.
The National Association of British and Irish Millers, Ltd.
The National Association of Flour Importers, Ltd.
The Naturopathic Association.
Group-Captain H. W. Pearson-Rogers, R.A.F. (Rtd.).
The Public Health Laboratory Service.
The Royal College of Physicians of London.
The Scottish Housewives' Association.
The Self Raising Flour Association.
The Soil Association.
Everard Turner, Esq., L.D.S.
Dr. E. M. Widdowson, D.Sc., Ph.D.

4.2. The Panel had the benefit of oral evidence from representatives of:—

The Baking Industry of the United Kingdom (trade associations and Research Association).
The Department of Health for Scotland (Scientific and Medical Advisers).
The Medical Research Council.
The Ministry of Agriculture, Fisheries and Food (Scientific and Medical Advisers).
The Ministry of Health (Scientific and Medical Advisers).
The National Association of British and Irish Millers, Ltd.

4.3. The following gave oral evidence in a personal capacity:—

Dr. W. I. M. Holman, Ph.D., F.R.I.C.
Dr. D. W. Kent-Jones, Ph.D., B.Sc., F.R.I.C.
Professor R. A. McCance, C.B.E., F.R.C.P., F.R.S.
Dr. E. M. Widdowson, D.Sc., Ph.D.

4.4. In addition to the written and oral evidence submitted to them, the Panel has had access to published work on the subject of their Terms of Reference.

Section 5

BACKGROUND

5.1. Before the war practically the whole of the nation's bread was made from white flour produced by the modern process of roller milling. This had been introduced round about 1880 and developed to its modern state during the first two decades of the present century(1). Pre-war practice was to produce for general commercial use a "straight-run" flour of 72 per cent. extraction(2), though where a more refined product was required "Patent" flours were available.*

5.2. This policy was, however, subject to criticism on nutritional grounds since the resulting flour, which was largely derived from the wheat endosperm, was recognised to be deficient in the vitamins of the B complex, notably in vitamin B_1. In the late thirties it was therefore suggested to the milling industry by Professor E. C. (now Sir Charles) Dodds that white flour might be enriched with synthetic vitamin B_1(4). The outbreak of war held up plans for implementing this proposal, but in July, 1940, the Government announced its intention to adopt the policy, and by March, 1942, nearly 40 per cent. of the country's white flour was in fact being so enriched.

5.3. At this stage the war-time shipping losses had, however, become so great that on supply grounds it was necessary to economise in the use of the available wheat by raising the extraction rate to 85 per cent., thus increasing the amount of flour available for human consumption. The inclusion of the additional 10 to 15 per cent. carried with it sufficient of the vitamin-rich portions of the wheat to render enrichment unnecessary. On the other hand the flour was, as a result of the inclusion of a larger proportion of the bran, distinctly darker and less attractive in colour.

5.4. From March, 1942, to September, 1944, the extraction rate was kept at 85 per cent. Meanwhile, investigations directed by Dr. T. Moran at the Cereals Research Station at St. Albans had shown that much of the vitamin content was concentrated in the scutellum (adjacent to the germ) and the aleurone layer (the inner layer of the branny coating of the endosperm). When, therefore, in October, 1944, supply considerations enabled the flour extraction rate to be lowered to 82½ per cent., the Ministry of Food was able, on the basis of methods worked out by the Cereals Research Station,

* A flour of 80 per cent. extraction is produced when 100 parts by weight of uncleaned wheat have been milled to give 80 parts by weight of flour. "Straight-run" 80 per cent. extraction flours consist of the whole of the combined mill streams other than 20 per cent. which is removed as offals and dirt. Before the war it was customary to produce flours of varying type by the appropriate selection of flour streams which ranged from the whitest ("Patent") streams at the top of the mill to darker flours from the later stages of the milling process. It is possible by appropriate selection of mill streams to produce a flour equivalent in nature to the "straight-run" 80 per cent. extraction flour. In "Patent" flours only the finest streams (representing some 20–40 per cent. of the original wheat) are blended. A brief description of this modern milling process is contained in the publication from which these definitions are taken.(3)

to advise millers of the need for including in the flour the germ (and particularly the scutellum) and for "cleaning" the bran in such a way as to include the maximum quantity of the aleurone layer([5]). The use of these improved techniques became even more important in January, 1945, when the extraction rate was further reduced to 80 per cent. It was then found possible to produce a near-white flour which still retained a reasonable proportion of the nutrients of the vitamin B complex.

5.5. From January, 1945, till August, 1953, limitations in wheat supply, due primarily to the country's adverse balance of payments position, controlled the extraction rate, which for four months in 1946 had to be raised temporarily as high as 90 per cent.; it remained throughout the following four years at 85 per cent. and was again lowered in August, 1950, to 80 per cent.*

The Conference on the Post-War Loaf, 1945

5.6. Meanwhile the Government had, in 1945, convened a representative Conference to assist Departments in advising Ministers on post-war bread and flour policy([6]). This Conference was unanimous in recommending that, on the decontrol of the milling industry, regulations should be made providing that all flours must contain not less than certain specified quantities of three so-called "token nutrients", namely, 0·24 milligrams of vitamin B_1, 1·60 milligrams of nicotinic acid and 1·65 milligrams of iron in 100 grams of flour. There was, however, a difference of view between the Government's advisers and the representatives of industry as to the means by which this objective should be achieved.

5.7. The Government's advisers considered that the three "token" nutrients should be looked on "only as elements in an organic complex which includes other substances some of which are known to be physiologically active, though knowledge of them is still imperfect"([7]). They felt that it was impossible, therefore, to be certain that artificially fortified flour would give nutritional results comparable to those from flour in which the known vitamins were retained together with the less well-known constituents of wheat. By implication they favoured the retention of a flour of 80 per cent. extraction, which would furnish the specified quantities of the "token" nutrients from the wheat itself, and considered that the addition of synthetic nutrients to lower extraction flours should be prohibited.

5.8. The industry's representatives, on the other hand, were not prepared to see such additions prohibited. They considered that there was no convincing evidence of the undesirability of the addition of nutrients, quoting as a precedent the fact that this process was in general use in the United States of America. Moreover, the Conference itself had acknowledged([8]) that there could be "no reasonable doubt that before the war the overwhelming preference of the public was for white bread", and had added that "experience at that time, when 95 per cent. of the bread sold was made of white flour, proved that any miller or baker who was not prepared to satisfy public demand for white bread would have lost trade to his competitors". The industry's representatives therefore urged strongly that on the grounds of consumer preference, as well as because of the acknowledged difficulties involved in the enforcement of an 80 per cent. extraction rate (and of certain other practical difficulties), there should be complete

* The flour was actually milled at 81 per cent. extraction to permit the addition of 10 per cent. of imported white flour. This addition diluted the nutrients to the level of roughly an 80 per cent. extraction.

freedom as to the method of attaining the specified levels of "token" nutrients.

5.9. In the hope of resolving these differences of view the members of the Conference did, however, unanimously agree that during the remaining period of control certain investigations should be undertaken, among which one of the most important was to be the determination of whether low extraction flour, suitably reinforced with the three "token" nutrients, could satisfactorily replace in the diet higher extraction flour in which the three "token" nutrients were obtained wholly from the wheat grain(9). The dietetic experiments carried out by Dr. E. M. Widdowson and Professor R. A. McCance in Germany in 1947–48, the results of which have been published by the Medical Research Council(10), were initiated for this purpose.

Government Policy following Decontrol of the Milling Industry

5.10. Early in 1953 it became clear that it would shortly be possible to decontrol cereals and to remove all restrictions from the milling industry. In these circumstances, and since the difference of opinion between the Government's advisers and the industry had not been resolved, the Government decided to adopt what was in essence a compromise proposal(11). To meet the views of the industry the Government agreed to permit the production of flours of any extraction rate provided that, where the extraction rate was below 80 per cent., the levels of the three "token" nutrients should be raised by the addition of synthetic nutrients to not less than the minima recommended by the Post-War Loaf Conference. On the other hand, the Government limited the payment of the subsidy on bread to that made from so-called National flours, i.e. flours of, or above, 80 per cent. extraction rate, because in the opinion of their advisers, these flours were of higher nutritive value than the lower extraction enriched flours. This policy was designed to give full freedom to the consumer to buy whatever type of bread he chose.

5.11. This compromise was accepted by the milling industry with one proviso. The industry pointed out that if there was (as they anticipated) a demand for "Patent" flours, it would be impracticable to meet such a demand unless they could dispose economically of the less refined flour mill streams which were produced in the course of "Patent" flour production. They therefore asked that they should be permitted to produce National flour by an appropriate selection of mill streams (so-called "divides") as well as by the "straight-run" process. Following an intensive investigation, the Government acceded to this request.

5.12. Effect was given to the Government's compromise policy (including the modification referred to in the previous paragraph) in the Flour Order, 1953(12), and the Bread Order, 1953(13). For the consumer the effect of these Orders was to provide the alternatives of *subsidised* National breads, made from flour of or above 80 per cent. extraction, at 7½d. per 1¾ lb. loaf, and *unsubsidised* breads, made from flours of extraction rates lower than 80 per cent. (in which, however, the "token" nutrients had been restored to the specified level) at 10½d. to 1s. 0d. per 1¾ lb. loaf. If a family of five, for example, should decide to purchase unsubsidised white bread instead of the subsidised National loaf, their weekly expenditure on bread (in terms of the national average of about 3 lbs. per head per week) would go up by about 2s. 6d. There was thus an appreciable monetary incentive in favour of the purchase of National bread. Household demands for National bread and breads made from flours of lower extraction are detailed in Appendix 1.

Of the total bread consumption both inside and outside the home, 91–92 per cent. is subsidised.

5.13. The Flour Order, 1953[12] defines National flour as follows:—

"'National Flour' means flour complying with the following conditions:—

(i) it shall contain the maximum quantity of wheat germ which, having regard to the type of milling, can be included in such flour;

(ii) it shall not include any coarse or added bran; and

(iii) it shall consist of wheat flour and shall either be of 80 per cent. extraction or shall be of substantially the same nature and contain substantially the same quantities and proportions of constituents as flour of 80 per cent. extraction."

When the Order was drafted, it was assumed that the normal range of composition of such flour would set practical limits to permissible variations and so enable infringement of the Order to be proved and appropriate legal action to be taken. In practice this has not proved feasible. Moreover, competition to meet the demands of bakers for white flours has been so keen that, without an effective means of enforcement, it has been impossible to prevent a progressive lowering of the extraction rate of National flour. Appendix 2 gives the results of analyses of bulked samples of flour by the Department of the Government Chemist in 1954 and in January to March, 1955. These results indicate that *in the periods covered by these figures, subsidised National bread was being made from a flour containing significantly less vitamin B_1, and slightly less nicotinic acid and iron, than was contained in the 70 per cent. extraction enriched flour used to make unsubsidised bread.* Moreover, added "token" nutrients have recently been found in a number of the samples of National flour contrary to the avowed intention of the Order* (see Appendix 2).

5.14. Possible methods of amending the Order so that its provisions could be enforced were later examined by a representative technical group. In subsequent discussions with the milling industry it became clear, however, that the industry was in fact still unwilling to accept as valid the significance from the point of view of human health of the nutritional considerations on which the Order itself was based, namely, that even with present-day diets a flour of 80 per cent. extraction is superior nutritionally to a flour of lower extraction in which the three "token" nutrients have been restored to the specified levels. The industry therefore urged that, before any amendment of the Order was considered, its whole nutritional basis should be reviewed, especially in the light of the Widdowson-McCance Report[10].

5.15. The Terms of Reference of the Panel were extended to include an assessment of the relative nutritive values of restored and unrestored low extraction flours. This was thought desirable because the findings of the Widdowson-McCance investigation in Germany were held by some to raise the whole question of whether any form of reinforcement of flour of low extraction is, in fact, necessary for adequate nutrition.

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* One of the recommendations of the Post-War Loaf Conference[14] was to ascertain whether methods could be devised for determining by examination of flour whether the "token" nutrients present were obtained wholly from the wheat grain or had been added in synthetic form. A test which achieves this objective in respect of vitamin B_1, which is now added in powder form, has been devised by Dr. J. J. C. Hinton of the Cereals Research Station[15].

FLOUR COMPOSITION AND NUTRITIVE VALUE

6.1. Such information as was available in 1949 on the content of the main nutrients occurring naturally, and of added creta praeparata, in flours of various extraction rates, is summarised in Appendix 3. These figures agree broadly with more recent information on the nutrient content of flours produced by commercial milling, except that the change in pantothenic acid figures with changes in extraction rate is now thought to be rather smaller than Appendix 3 suggests.

6.2. The evidence before the Panel has emphasised the concept that the composition and nutritive value of flour should be considered together rather than separately. The amount of a substance which is present may be determined with precision by the methods of quantitative analysis, but the gross amount so revealed may include a variety of forms not all of which are equally available for absorption from the digestive tract. Moreover, the use actually made of a potential nutrient or accessory food factor may be influenced by the presence or absence of similar or associated substances in the same article or other articles of the diet. The value of one constituent of the diet may be influenced by the presence of another. Thus, whilst it is convenient and necessary to review the composition of flours item by item, a just estimate of the nutritive value of individual components must take into account their importance relative to the diet as a whole.

6.3. The definition of National flour in the Flour Order, 1953([12]) is in terms of an "extraction rate". The extraction rate of flour is specially referred to in the Panel's Terms of Reference, and the Panel have, therefore, paid particular attention to the suitability of the extraction rate as an index of the composition of flour.

The extraction rate is the proportion which the output of flour bears to the wheat from which it is derived. When only one grade of flour is being made —a "straight-run" flour—the extraction rate can be stated with accuracy by the miller and confirmed by inspection of appropriate records. This system prevailed during the period of control of the milling industry from 1939 to 1953. If the miller wishes to make two or more grades of flour simultaneously he may select certain of his mill streams and blend them at will. The term extraction rate cannot accurately be applied to the products of this selection. The miller may, however, select mill streams in such a way as to produce a flour as nearly as possible equivalent to a flour of a known extraction rate. In this way National flour "by divides" is produced. If a mill is set to give an overall extraction rate of, say, 76 per cent. the whitest part of the flour from the upper mill streams can be removed as low extraction flour so that the remaining portion will be approximately equivalent to an 80 per cent. extraction flour. Although there are other technical means of determining equivalent extraction rates, it would appear that the miller's main routine guide is the colour of the flours produced.

6.4. A true 80 per cent. "straight-run" flour varies in composition and appearance according to the character of the wheat from which it is derived and the method of milling. Wheat composition is affected by variety, season and cultural conditions, moisture content and the amount of foreign matter present. The shape of the grain affects the degree of separability of the bran and the aleurone layer. The machinery available in the mill also affects the degree to which it is possible to separate the endosperm, the scutellum and the germ from the bran.

6.5. Because of these differences even "straight-run" 80 per cent. extraction flours must vary significantly in composition, and the differences may be increased in milling an equivalent 80 per cent. extraction flour (i.e. a National flour by the "divides" method), for here the miller relies to a great extent on his own assessment of equivalence.

6.6. The phrase in the Panel's Terms of Reference "flour of extraction rates less than National flour" covers a range of flours and cannot therefore be linked to any standard of natural composition. The Panel has accepted with reservations flour of 70 per cent. extraction as a reference point among lower extraction flours. The available evidence on the composition of samples of flour of this description does not suggest that they show a high degree of uniformity, and the complexity of the milling process makes it doubtful whether specially milled samples such as were used in the Widdowson–McCance diets[10] can be accepted as strictly comparable with commercial flours.

6.7. The Department of the Government Chemist has very comprehensive records of estimations of the more important components of flour, including data from periods when the extraction rate was strictly controlled. It has records of more extended investigations on various grades of flour since decontrol (see Appendix 2). The usefulness of these data, in assessing the variation in composition associated with changes in the extraction rate, is seriously limited, however, by the absence of reliable information on the true extraction rate of the flours examined. *The Panel believes that the immediate drop in the vitamin B_1 and nicotinic acid content of National flour after decontrol and the continuing fall since, have resulted primarily from deliberate disregard of the intention of the Flour Order rather than from such factors as variations in the character of the wheat from which the flour was milled, although these factors may have played a secondary role.* This matter is discussed further in paragraph 6.9.

6.8. It is not possible to prove whether any given sample of flour does or does not conform with the Flour Order definition of National flour (see paragraph 6.3). Hence the composition of flour complying with the Flour Order is not in fact a defined composition. In considering paragraph (1) (*a*) of their Terms of Reference, therefore, the Panel has had to take into account, firstly, National flour of the composition envisaged by the Conference on the Post-War Loaf, and secondly, flour being sold during 1955 as National flour.

6.9. Evidence submitted by the Department of the Government Chemist indicates that enriched low extraction flour contains "token" nutrients in amounts which are reasonably close to the requirements laid down in the Flour Order, whereas National flours milled in 1954 and 1955, whether "straight-run" or by "divides", were notably below the required levels in Vitamin B_1 and slightly lower in nicotinic acid. Enriched low extraction flours were sometimes low in iron. Details are given in Appendix 2.

Protein

6.10. The amount of protein present in flour falls as the extraction rate falls. As an illustration of the extent of this variation some figures given by Dr. D. W. Kent-Jones[16] may be quoted. For "Patent" flour (about 50 per cent. extraction), for 72 per cent. "straight-run" flour and for 80 per cent. "straight-run" flour he gives protein contents of 10·0, 11·0 and 11·4 per cent. respectively. The digestibility of the protein, which is estimated by comparing the amount of protein in the faeces of rats with the amount of protein in their food, increases as the extraction rate is reduced.

The biological value of the protein, based on the percentage of nitrogen retained by young rats from a diet containing protein from only one source, decreases as the extraction rate is reduced. Protein quality can also be assessed by Net Protein Value, compounded from the digestibility, the biological value and the concentration. On this basis 80 per cent. flour has a slightly greater Net Protein Value than 70 per cent. flour[17], but the figures obtained are themselves dependent on a number of assumptions. For man on a mixed diet the synergic influence of proteins in other foods reduces the significance of animal experiments in which all the protein comes from one source.

6.11. The nutritive quality of a protein will depend on the relative amounts in which certain essential amino-acids are present and are made available on alimentary digestion. In the case of wheat proteins the limiting amino-acid is lysine and the proteins of the germ and bran yield proportionately more of this than those of the endosperm. 80 per cent. extraction flour is thus a slightly richer source of lysine than 70 per cent. extraction flour. Weanling rats are sensitive to the amount of lysine in their diet, as shown by the fact that the rate of growth is more rapid with high as opposed to low extraction flours when these are fed as the sole source of protein[18], and in similar experiments in which the low extraction flour is supplemented with lysine itself (unpublished results from the Cereals Research Station). Nevertheless Dame Harriette Chick and Dr. Slack[18] found that the proteins of 70 per cent. and 80 per cent. extraction flours were about equally efficient for building the tissues of the growing rat.

6.12. Data to be discussed later (paragraph 7.8) show that where there are three or more children in families there has been in recent years a tendency for the total protein intake to fall below the allowance recommended in the Report of the British Medical Association[19]. This allowance was computed on an energy basis, and the Committee concerned emphasised that this took no account of protein *quality* but was an intelligent guess as to the *quantity* of protein which would cover man's needs. For pregnant and nursing women, infants, children and adolescents they recommended that 14 per cent. of the calories in a mixed diet should be in the form of protein ; for other adults not engaged on hard work the recommendation was 11 per cent. of calories as protein. In the Widdowson and McCance investigation[10] the groups of children at Duisburg fed with products from 70 per cent. extraction flour obtained 12·0 per cent. of their total calories from protein. The corresponding group at Vohwinkel obtained only 8·8 per cent. from the same source. Yet growth was excellent at both centres and in no way inferior to that of groups of children fed from flours of a higher rate of extraction. Both diets provided lysine in excess of the allowance deemed adequate for the maintenance of nitrogen equilibrium by Rose *et al*[20], but the amount derived from sources other than flour was large enough to obscure any difference between the various flours concerned. The experiments nevertheless demonstrated that the protein of 70 per cent. extraction flour, when blended with the proteins of the other foodstuffs of the diet, constituted a dietary component for the growth of these children which was as satisfactory as that from flours of higher extraction.

Carbohydrate

6.13. Information supplied by the Department of the Government Chemist has shown clearly an increase in the carbohydrate content with decrease of extraction rate. Most of this increase is in the form of starch. There is a smaller absolute but much larger proportionate decrease in sugar content.

Cellulose and pentosans are little changed in the range from National to lower extractions, but are higher in brown flours.

Vitamin B_1

6.14. Over the range of extraction rate from 80 per cent. to 70 per cent. there is undoubtedly a lowering of the vitamin B_1 content of flour. There is convincing evidence[21] that during 1945 millers produced an 80 per cent. flour of which the vitamin B_1 content agreed closely with the level stated by the Conference on the Post-War Loaf. It is acknowledged, however, that variation in the grist may lead to unavoidable variation in the vitamin B_1 levels obtainable in the flour, and it is also recognised that both mills and millers vary in their capacity to maintain the highest possible levels of vitamin B_1 at a given extraction rate without detriment to the technical quality of their product. It is apparently possible for 70 per cent. flour to contain almost as much vitamin B_1 as some 80 per cent. flours. Nevertheless the Panel is satisfied that in the ordinary run of commercial milling 70 to 72 per cent. extraction flour normally contains markedly less vitamin B_1 than 80 per cent. extraction flour (see Appendix 3). Appendix 4 indicates levels of vitamin B_1 reported by different investigators in 70 per cent. or 70 to 72 per cent. extraction flour. Vitamin B_1 is one of the three nutrients added in accordance with the Flour Order, 1953[12], to low extraction flour used in this country. These additions should bring the vitamin B_1 content of the flour up to 0·24 milligrams per 100 grams of flour.

6.15. No evidence has been produced to indicate that synthetic or added vitamin B_1 is less effective as a nutrient than vitamin B_1 occurring naturally. The contribution of Dr. W. I. M. Holman to the Widdowson-McCance Report[10] suggests that synthetic vitamin B_1 is less stable during baking than naturally occurring vitamin B_1. Experiments by the Government Laboratory showed no appreciable loss of vitamin B_1 on baking, but the British Baking Industries Research Association claim that about 20 per cent. is lost during bread baking and about 30 per cent. is lost during cake-making, independent of the extraction rate of the flour or the source of the vitamin. The National Food Survey calculations include an allowance of 15 per cent. on vitamin B_1 for cooking losses over and above the general allowance of 10 per cent. for losses between retail purchase and actual consumption.

Nicotinic Acid

6.16. There is no doubt that there is less nicotinic acid in flours of lower extraction than in flours of 80 per cent. extraction (see Appendix 3), but the proportionate difference between 80 per cent. and 70 per cent. extraction flours is smaller than for vitamin B_1. The factors which lead to variation and uncertainty in the case of vitamin B_1 contents of flours also apply to some extent to nicotinic acid. In addition, the analytical data available are derived partly from chemical analysis and partly from microbiological assays, the latter method tending to give lower results on cereal products. The analytical findings do not indicate the form or forms in which the nicotinic acid is present, nor the extent to which the nicotinic acid can be used by man, for in wheat products, as in maize products, the nicotinamide* present occurs in a bound form which cannot be utilised by the animal[22]. There is good evidence, moreover, that nicotinic acid can be synthesised in

* Nicotinic acid, when taken by mouth, is partly converted to nicotinamide, and it is in this form that it functions as a vitamin. Analytical methods in the main fail to distinguish between these two forms. In biochemical researches, both forms have been used.

the body from tryptophan (see paragraph 6.22) which is supplied in adequate amount by the various proteins of flour. There does not appear to be any marked loss of nicotinic acid during baking.

6.17. Nicotinic acid, like vitamin B_1, is added to low extraction flour used in this country, the minimum content specified in the Flour Order, 1953([12]) being 1·60 milligrams per 100 grams of flour. Metabolic balance studies forming part of the Widdowson-McCance investigation suggest that synthetic nicotinic acid may have been more readily absorbed than that occurring naturally in wholemeal flour.

Riboflavin

6.18. The riboflavin content of flour falls as the extraction rate falls from 80 per cent. to 70 per cent. (see Appendix 3), but the difference is comparatively small. The studies of riboflavin excretion in the Widdowson-McCance experiment at Vohwinkel([10]) suggest that it was riboflavin which was nearest to the critical level, particularly in the diet containing unenriched low extraction flour. There appears to be no loss of riboflavin in baking normal bread, but some might be lost in baking the rather unusual types of bread which are markedly alkaline. In America, riboflavin is added to flour so as to bring the riboflavin content of the flour up to a minimum of 0·26 milligrams per 100 grams. In the United Kingdom riboflavin is not added to flour compulsorily.

Pyridoxine, Pantothenic Acid, Biotin and Folic Acid

6.19. Evidence was submitted that these accessory food factors occurred in lower concentrations in lower extraction flour, but no figures appear to be available comparing average 70 per cent. " straight-run " flours with average 80 per cent. " straight-run " flours. Dr. D. W. Kent-Jones (Appendix 3) has given a series of figures indicating the trend of three of these nutrients in flours of different extraction rates. As explained in paragraph 6.1, more recent data supplied to the Panel confirm the pattern of these results, except that the change in pantothenic acid figures with changes in extraction rate is now thought to be rather smaller than Appendix 3 suggests. Analyses made by the Department of the Government Chemist on different series of flours, not themselves directly comparable, are given in the following Table:—

TABLE 1

Composition of Flours of Various Extraction Rates (per 100g.)

	Patent	Below 80 per cent., probably about 70 per cent.	Straight-run 80–81 per cent.	National *brown* below 93 per cent.	Wholemeal
Pyridoxine (mg) ...	0·11	Not available	0·29	Not available	Not available
Pantothenic Acid (mg)	0·33	0·33	0·37	0·81	0·92
Biotin (mg)	0·0005	0·0011	0·0023	0·007	0·008
Folic Acid (mg) ...	0·012	Not available	0·026	Not available	Not available

(Source: Department of the Government Chemist).

6.20. The figures quoted are thought to give a good indication of the probable content of flours but are not sufficiently well founded to be regarded as standards. They lead to the conclusion that the drop from 80 per cent. to 70 per cent. extraction may have little effect on the pantothenic acid content of the flour but would reduce the pyridoxine, folic acid and biotin levels.

6.21. From the food consumption levels of the 1952 National Food Survey([23]), together with the data given by Bicknell and Prescott([24]) and in the United States Department of Agriculture Handbook No. 29([25]), the percentage contributions of different groups of food to the dietary intakes of pyridoxine, pantothenic acid, biotin and folic acid have been estimated. On these data an 80 per cent. extraction flour provides 39 per cent. of the pyridoxine, 18 per cent. of the pantothenic acid, 14 per cent. of the biotin and 28 per cent. of the folic acid in the diet. For a "Patent" flour (of, say, 40 per cent. extraction) the corresponding figures would be 19, 16, 4 and 15 per cent. respectively. These percentages are, of course, simply approximations but they give a fair impression of the contribution of bread to the total intake of these nutrients.

6.22. Evidence for the need of a regular intake of pantothenic acid is indirect but not unconvincing. Little is known about the quantitative needs of this vitamin, but 5 milligrams per 1,000 calories has been suggested([26]), and this would appear to be met in normal diets as pantothenic acid is well distributed in various foods. Pyridoxine is known to be a needed catalyst in many metabolic reactions, of which the conversion of tryptophan to nicotinamide (see paragraph 6.16) is an example.

Phytic Acid

6.23. The Department of the Government Chemist have supplied data on the phytic acid content of flours. There is less phytic acid in the flours of lower extraction. Phytic acid is regarded as an anti-nutrient because it renders part of the calcium content of a diet unavailable. The difference in phytic acid content between flours of 80 per cent. and of lower extractions is very small in relation to the amount of calcium added to such flours.

Calcium

6.24. Since calcium is added, in the form of creta praeparata, to both National and lower extraction flours in amounts which offset any difference in the naturally occurring calcium content of these flours, the variations in amount or nutritional value of this component do not come within the Terms of Reference of the Panel. This addition of creta praeparata was originally made in order to offset the high phytic acid content of flour when an extraction rate above 80 per cent. was compulsory. It also provides a valuable addition to calcium intakes in amounts which ensure an adequate supply.

Iron

6.25. Low extraction flours contain less iron than 80 per cent. extraction flours but the extent of the difference is subject to the same uncertainty as for other components. There is a lack of evidence on the availability of the iron which may be present, and there is no evidence that more iron is absorbed from a flour of 80 per cent. extraction than from a flour of 70 per cent. extraction.

6.26. Iron is the third of the nutrients compulsorily added to low extraction flour used in the United Kingdom. The minimum content specified in the Flour Order, 1953([12]) is 1·65 milligrams per 100 grams of flour. American studies([37]) have indicated that the iron in bread made from flour enriched in this way is absorbed to the same extent as other forms of iron in the food and makes a significant contribution to the individual's intake of iron. There is no material difference in the availability of iron in the various compounds commonly used for the purposes of enrichment.

Other Mineral Components

6.27. According to data supplied by the Department of the Government Chemist, the sodium, magnesium and manganese contents of flour all vary

with the extraction rate. These elements play a part in human nutrition, but the difference in the contribution made by flours of different extraction rates to the total intake and dietary requirements of these elements is so small as to be negligible.

Section 7

THE CONFLICTING VIEWS

7.1. The Panel is spared by its Terms of Reference from discussing various dietetic creeds which have been brought to its notice, based on the alleged superiority of such breads as "wholemeal" and "pure white". It conceives that its most important task is to decide on the evidence between the conflicting views which have been expressed on the contribution of flour of 80 per cent. extraction, and flour of lower extraction rate, for which the Panel has taken 70 per cent. extraction as a convenient and practical example.

7.2. Briefly, the Government's medical and scientific advisers and the Medical Research Council claim that, since bread contributes, on a national average, one-third of the total calories of the diet, National flour of 80 per cent. extraction makes it virtually certain that the diet as a whole will provide an adequate supply of protein, vitamin B_1, nicotinic acid and iron and that, in addition, such flour provides useful quantities of other essential nutrients for which there are less well defined criteria of adequacy. If the extraction rate were lowered to 70 per cent. there would be a loss of protein, vitamin B_1, nicotinic acid and iron, and, even if these two vitamins and iron were restored by enrichment, a reduced intake of other vitamins might in some circumstances be reflected in nutritional deficiencies.

The representatives of the industry, on the other hand, claim that between National flour of 80 per cent. extraction and whiter flour of lower extraction, enriched with vitamin B_1, nicotinic acid and iron to the levels obtaining in National flour, any differences in composition are insignificant when related to the diet as a whole. There are additional arguments on both sides, to which reference will be made later, but this is the main difference of opinion before the Panel.

Nutritional Requirements

7.3. In considering the nutritional status of the population the recommendations of the Report of the Committee on Nutrition, published by the British Medical Association in 1950[19], have provided a series of reference points. This Committee were careful to draw attention to the limitations of their own conclusions, but nevertheless put forward estimates of energy requirements and quantities of various nutrients which they believed sufficient to establish and maintain a good nutritional status in representative individuals of the groups concerned. They recognised that in every group there must be cases where the need for one or other nutrient is greater than average[27]. The Panel has borne in mind the qualifications attached to the relevant British Medical Association estimates in considering the data put before it. Dietary allowances recommended by the National Research Council of America[28] and Canadian Council on Nutrition[29] are substantially in agreement with those of the British Medical Association, insofar as these are relevant to the Panel's Terms of Reference. The three sets of recommendations (for nutrients with which the Panel is concerned) are shown in Appendix 5. It must be stressed that all these recommendations contain arbitrarily assessed margins of safety.

7.4. The recommended allowances are stated in terms of the diet as a whole, but take no account of the proportion of the allowances to be supplied by individual foods.

The Arguments Advanced for 80 per cent. Extraction Flour

7.5. Bread is the most important staple food in the British diet. Before decontrol bread and flour together supplied about a third of the energy value, the protein, the vitamin B_1, the nicotinic acid and the iron of the total food intake. About three-quarters of the flour was consumed in the form of bread. Before the Second World War the annual consumption of flour was 195 lbs. per head; by 1945 this had risen to a maximum of 241 lbs. per head. Since then it has fallen to 187 lbs. per head in 1954, while at the same time, consumption of meat, bacon, cheese and sugar has risen.

7.6. Bread and flour are particularly important items in the diet of large families. The following Table 2 shows for 1953 the greater contribution of bread and flour, to energy value and nutrients, in the diets of households with four or more children, than of those with one child.

TABLE 2

CONTRIBUTION OF BREAD AND FLOUR TO THE ENERGY VALUE AND NUTRIENTS OF THE DIET, 1953

	Calories	Protein	Vitamin B_1	Nicotinic Acid	Iron
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Households with one child ...	26	29	31	27	24
Households with four or more children	30	35	36	31	29

(Source: Report of the National Food Survey Committee, 1953([30])).

7.7. A broad picture of the adequacy of nutrition of the population as a whole is obtained from a comparison of the energy value and nutrients of the whole diet with British Medical Association recommendations (Table 3). Figures of nutrient intake have been calculated from details of purchases of food for household consumption, extracted from the Report of the National Food Survey Committee, 1953([30]). The figures of nutrient intake include a general allowance of 10 per cent. for wastage between purchase and consumption.

TABLE 3

ENERGY VALUE AND NUTRIENT CONTENT OF DOMESTIC FOOD CONSUMPTION EXPRESSED AS PERCENTAGES OF STANDARDS BASED ON THE BRITISH MEDICAL ASSOCIATION'S RECOMMENDATIONS

All Households, 1953

	1952 Yearly Average	1953				
		1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Yearly Average
Energy Value	99	99	100	102	103	101
Total Protein	104	105	104	105	106	105
Vitamin B_1	131	131	130	135	131	132
Nicotinic Acid	131	135	129	137	138	135
Riboflavin	109	110	109	110	110	110
Calcium	108	109	111	106	107	108
Iron	106	104	106	109	108	107

(Source: Report of the National Food Survey Committee, 1953([30])).

It must be remembered, however, that these are average values. Where the mean is just adequate it follows that a significant section of the population are getting less than the recommendations. Some people eat less than the

average because they need less, but an examination of the data for groups classified according to size of household indicates that differences in individual needs do not wholly explain intakes below the average.

7.8. Table 4 indicates that intakes of nutrients below the general average are most likely to occur in large families. In this Table the yearly average data for 1953 have been broken down according to households of various sizes. An increase in the number of children in the household is reflected in below-average intakes of some nutrients.

TABLE 4

ENERGY VALUE AND NUTRIENT CONTENT OF DOMESTIC FOOD CONSUMPTION EXPRESSED AS PERCENTAGES OF STANDARDS BASED ON THE BRITISH MEDICAL ASSOCIATION'S RECOMMENDATIONS

Classification by Size of Household, 1953

	Households with one male and one female adult and					
	Children only*				Adoles-* cents only	Adoles-* cents and children
	1	2	3	4 or more		
Energy Value ...	107	102	99	100	99	95
Total Protein ...	112	102	95	93	101	89
Vitamin B_1	139	131	127	128	130	121
Nicotinic Acid ...	142	130	124	122	134	121
Riboflavin	120	113	107	101	104	95
Calcium	115	102	92	87	107	92
Iron	116	106	103	100	110	100

(Source: Report of the National Food Survey Committee, 1953 ([30])).

7.9. In 1953 flour was of 80 per cent. extraction for eight months and subsequently was governed by the Flour Order, 1953([12]). The situation would have appeared less satisfactory had unenriched 70 per cent. extraction flour alone been available instead of 80 per cent. extraction flour. Table 5 shows what the effect of this change would have been:—

TABLE 5

EFFECT OF 70 PER CENT. EXTRACTION FLOUR ON INTAKES OF CERTAIN NUTRIENTS BY HOUSEHOLD COMPOSITION EXPRESSED AS PERCENTAGES OF BRITISH MEDICAL ASSOCIATION'S RECOMMENDATIONS

1953	Extraction Rate of Flour	Households with one male and one female adult and					
		Children only				Adolescents only	Adolescents and children
		1	2	3	4 or more		
Vitamin B_1	80%	139	131	127	128	130	121
	70%	111	106	100	99	102	96
Nicotinic Acid	80%	142	130	124	122	134	121
	70%	127	116	108	106	118	105
Iron	80%	116	106	103	100	110	100
	70%	110	101	96	94	104	95

(Source: Report of the National Food Survey Committee, 1953 ([30])).

* Definitions:—
Child ... ... up to fifteen years of age.
Adolescent ... fifteen to twenty years of age, inclusive.

7.10. If the intake figures for nutrients, expressed as a percentage of British Medical Association recommendations, are classified by income of the head of the household, a tendency for the adequacy of the diet to fall with income is discernible, though there are no serious signs of deficiency. The figures are given in Table 6.

TABLE 6

ENERGY VALUE AND NUTRIENT CONTENT OF DOMESTIC FOOD CONSUMPTION EXPRESSED AS PERCENTAGES OF BRITISH MEDICAL ASSOCIATION RECOMMENDATIONS

Classification by Income of Head of the Household

	Income Group*							
	A	B	C	D				All Households
				Excluding O.A.P.		O.A.P.	All D	
				With Earners	Without Earners			
Energy Value...	103	102	101	98	104	107	100	101
Total Protein...	112	105	103	104	115	119	108	105
Vitamin B_1 ...	139	134	130	129	136	136	131	132
Nicotinic Acid	153	137	132	131	142	139	133	135
Riboflavin ...	127	113	107	104	118	114	107	110
Calcium ...	114	107	107	109	113	114	110	108
Iron	111	110	109	103	96	94	102	107

(Source: Report of the National Food Survey Committee, 1953 ([30])).

7.11. In 1953 the price of bread was controlled, and the extraction rate was 80 per cent. In the nineteen-thirties the price was uncontrolled and the extraction rate was about 70 per cent. By combining data on food intake by income groups, used by Lord Boyd Orr in 1936, with more recent data on flour composition it is possible to calculate the intake of certain nutrients by the main income groups of that time (see Table 7).

It is claimed that it is therefore possible that, if neither the price of bread nor the extraction rate of flour were controlled, and if enrichment were not compulsory, the lower income groups might again suffer serious lack of "token" nutrients.

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* Definitions—

Class A ... ... gross weekly income of head of household exceeds £15
Class B ... ... gross weekly income of head of household £9–£15
Class C ... ... gross weekly income of head of household £6–£9
Class D ... ... gross weekly income of head of household under £6
O.A.P. ... ... Old Age Pensioner households

TABLE 7

PRE-WAR INTAKE OF THREE "TOKEN" NUTRIENTS BY INCOME GROUPS
PERCENTAGE COMPARISONS

	mg. per head per day (all households)	Calculated Intake of Individual Income Groups* as a percentage of Intake of all Households					
		I	II	III	IV	V	VI
Vitamin B_1 ...	1·3	77	91	99	104	110	119
Nicotinic Acid ...	13·1	72	88	98	107	112	117
Iron	13·2	75	90	99	106	110	114

(Source: Ministry of Food ([31])).

7.12. Economic hardship encourages the consumption of the cheaper varieties of food. It is desirable that bread, which is at present a cheap source of calories and nutrients, should not become deficient in nutrients. It is feared that there is already a tendency for too large a proportion of the diet to be devoted to "empty" calories derived from fat and carbohydrate and too little to protein and the protective vitamins which should normally accompany the protein.

7.13. The Conference on the Post-War Loaf([7]) stated clearly the opinion of its scientific and medical members that vitamin B_1, nicotinic acid and iron were to be regarded as tokens of other nutrients associated with them, but which at that time had not been fully investigated. It was held that the whole complex of vitamins and not simply the "token nutrients" had been effective in maintaining the high standard of health throughout the preceding war years. Since 1945 more knowledge has been obtained on the distribution and functions of pyridoxine, pantothenic acid, biotin and folic acid. Animal experiments suggest that these nutrients are essential for human nutrition, and it is claimed that well defined deficiency states in man, due to lack of pyridoxine([32]) and biotin([33]) can be recognised. The need for pantothenic acid([34]) and folic acid in human nutrition has also been demonstrated. It is therefore unwise in the present state of knowledge to adopt any measure which would diminish intake of these nutrients.

7.14. The social habits of a community change, and the effects of these changes on food problems are not always immediately evident. Economic conditions also may change and food habits with them. Sudden emergencies can be met by the introduction of emergency measures but less dramatic changes are not readily countered by administrative action. Although a need for action may be recognised its wise timing may be extremely difficult.

7.15. The medical and scientific advisers to the Government insist that if there is any uncertainty about a nutritional policy it is better to err on the side of caution. They believe that nothing is gained in terms of

* Definitions—

Group I ...	estimated pre-war income per head per week	up to 10s. 0d.
Group II ...	estimated pre-war income per head per week	10s. 0d. to 15s. 0d.
Group III ...	estimated pre-war income per head per week	15s. 0d. to 20s. 0d.
Group IV ...	estimated pre-war income per head per week	20s. 0d. to 30s. 0d.
Group V ...	estimated pre-war income per head per week	30s. 0d. to 45s. 0d.
Group VI ...	estimated pre-war income per head per week	over 45s. 0d.

the health of the population by providing flour of lower extraction, even when enriched with the three " token " nutrients, in place of well-made flour of 80 per cent. extraction, and that something may indeed be lost.

The Arguments Advanced for Enrichment

7.16. It is not possible to determine the extraction rate of a commercial sample of flour with accuracy, and unless it is a " straight-run " flour even the term " extraction rate " is not strictly applicable. It is generally agreed that the Flour Order, 1953([12]) has not been enforced. This Order says that National flour " shall either be of 80 per cent. extraction or shall be of substantially the same nature and contain substantially the same quantities and proportions of constituents as flour of 80 per cent. extraction ".

The object of the second alternative was to allow National flour to be economically produced by mixing millstreams. The fact that the Order does not say which constituents are important or what quantities should be present in National flour has meant that small infringements could not be proved. The desire of bakers for whiter flour to produce the whiter bread which their customers prefer (but which would still attract the subsidy on National bread) has led to a form of competition in which the composition of National flour has changed from the equivalent of 80 per cent. extraction to the equivalent of about 74 per cent. extraction. This change has been widespread and gradual and this fact, combined with the enforcement difficulties, has made it impossible for the Government to stop the trend. Judging appearance by grade colour, the 80 per cent. flour made before decontrol had a rating of between 5·5 and 6·0 units. The average value for National flour samples taken in January, 1955, was 3·7 and in October, 1955, 3·1.*

7.17. Flour of 80 per cent. extraction is regarded by the industry as being of poor technical quality. Bread made from it is neither white nor brown, but tends to be grey. The flour is unpopular with millers, bakers and the makers of cakes and biscuits. As traders, these supply, as best they can, what the public wants, and as craftsmen they are anxious to maintain the traditional quality of their products. They claim to be expert judges of present public demand and of the technically desirable characteristics of flour. They admit a demand for wholemeal and for brown flour, a much greater demand for white flour and a strong preference for the whitest flour available at a competitive price.

7.18. Although flour is such a major factor in nutrition there is no need for it to be a complete food in itself. The value of flour is enhanced by contributions from the remainder of the diet. If it is desirable, for overall nutritional convenience, to maintain stated levels of nutrients such as vitamin B_1, nicotinic acid and iron, it is technically possible for these to be added to the flour as required. The millers' scientific advisers consider it unnecessary and unrealistic to insist that flour should also contain relatively high but unspecified levels of other nutrients of which there is no evidence of shortage and no accurate knowledge of needs.

7.19. The millers' representatives at the Conference on the Post-War Loaf([6]) did not agree with the contention of the scientific and medical representatives that these other nutrients were of importance and it was agreed that this idea should be tested by experiment. The work of Dr. E. M. Widdowson and Professor R. A. McCance in Germany([10]) was originally planned to provide such a test. The results, however, failed to demonstrate

* The darker the flour, the higher the colour grading.

nutritional advantages of flours of higher extraction rates over lower extraction flour fortified with vitamin B_1, nicotinic acid and iron. Flour producers and flour users are of opinion that nutritional problems arising from the demand for a lower extraction flour can be met adequately by a policy of enrichment. This would not present the same difficulties as a policy of 80 per cent. extraction flour and would also ensure a more constant level of vitamin B_1, nicotinic acid and iron in flour and a greater degree of liberty to those individuals who prefer bread made from flour of superior technical quality.

7.20. Makers of cake and biscuits are at present the chief users of the enriched flour of extraction rate lower than 80 per cent. They are anxious that flour of such grade should continue to be available to them as they consider it essential to the quality of many of their products, and especially of those which are exported. The enrichment of such flours has no technical disadvantages for them.

7.21. The milling and baking industries therefore consider that a National flour of 80 per cent. extraction has no greater virtue nutritionally than an enriched lower extraction and whiter flour and that the 80 per cent. extraction flour has technical disadvantages. They oppose the confining of the subsidy to National bread only, because this influences the consumer in his choice of bread.

7.22. The Panel believes that the foregoing paragraphs summarise accurately and fairly the two points of view which have been expressed in the evidence, and the arguments which have been brought in support of them.

Section 8

THE WIDDOWSON AND McCANCE REPORT

8.1. The Conference on the Post-War Loaf([6]) recommended—

> " . . . that during the remaining period of control each of the practical difficulties to which reference has been made in the Report should be vigorously studied . . . The particular items requiring investigation are:—
>
> (1) How low extraction flour suitably reinforced with the "token" nutrients compares from a nutritional point of view with high extraction flour obtained wholly from the wheat grain. In this connection consideration will, of course, have to be given to information which may be available as to the results of the widespread use of reinforced flour in the United States . . ."

A Cereals Research Sub-Committee of the Accessory Food Factors Committee of the Medical Research Council found it possible in 1946 to make use of the facilities of a Medical Research Council Unit at Wuppertal and two orphanages at Duisburg and Vohwinkel in conducting an experiment on the nutritive value of bread.

8.2. The original proposal was to compare 85 per cent. extraction flour with a white flour enriched with vitamin B_1, riboflavin, nicotinic acid and iron up to the levels naturally present in 85 per cent. extraction flour. Unenriched 70 per cent. and 100 per cent., and 70 per cent. extraction flour enriched to the 100 per cent. level were also finally included. At Duisburg all five flours were tested, but at Vohwinkel only the 100 per cent., the 70 per cent. unenriched, and the 70 per cent. enriched to the 100 per cent. level were tested.

8.3. The children were undernourished in the sense that they were short of calories, but were well supplied with vitamins. It was thought desirable to reduce these vitamin reserves by a short preliminary period on 70 per cent. unenriched flour.

8.4. In the preliminary period, and throughout the experiment, the children were weighed and measured at regular intervals, and chemical, haematological, biochemical, radiological and dental examinations were made. During the experiment, lasting one year, records were also kept of the composition of the diets and the amounts consumed, and metabolic balances were studied for sample children in each group.

8.5. Bread provided 75 per cent. of the calorie intake of the children at Duisburg, 35 per cent. at Vohwinkel; the remainder of the diet was largely of vegetable origin and it was originally thought that the lack of animal protein might be felt. The following Table 8 shows the proportion of other nutrients provided by bread and flour at Duisburg and at Vohwinkel:—

TABLE 8

PERCENTAGE OF NUTRIENTS SUPPLIED BY BREAD AND FLOUR IN THE GERMAN EXPERIMENTS

Orphanage	Nutrient	Extraction rate of flour (per cent.)				
		100	85	70	70 Enriched to 100	70 Enriched to 85
Duisburg ...	Vitamin B_1 ...	73	68	49	69	67
	Nicotinic Acid	78	63	53	75	66
	Riboflavin ...	70	58	38	58	54
Vohwinkel ...	Vitamin B_1 ...	53	—	30	52	—
	Nicotinic Acid	53	—	35	53	—
	Riboflavin ...	31	—	12	23	—

(Source: Medical Research Council Special Report Series No. 287([10])).

8.6. A supplementary experiment was carried out at Duisburg to determine the effects of increasing the milk available to children.

8.7. Experiments were also carried out on rats and two of the diets were tested on pigs.

8.8. The conclusions of the investigators were as follows:—

"The first conclusion to be drawn from this report is unquestionably that the greatest caution must be exercised in coming to any conclusion at all. Any conclusions that may be drawn must be restricted to the setting in which the scientific evidence was obtained.

Under the particular conditions of the experiments reported here no difference could be detected between the nutritive value of the different breads except when they were given to weanling rats. Probably the most important finding concerns the high nutritive value of wheat in any of the forms customarily consumed by man. Thus it has been shown that diets in which 75 per cent. of the calories were derived from wheat flour and 21 per cent. from vegetables, and which contained only 8 grams of animal protein a day, provided undernourished children aged 5–15 years with all the nutrients required for a high rate of growth and development for a period of 18 months.

The addition of 500 milligrams of reconstituted full-cream dried milk per day over a period of 6 months caused no apparent improvement in the growth or health of the children. It is evident that diets containing much bread and little animal protein can be made highly satisfactory, and that a balanced diet, adequate in all its nutritional aspects, can be provided with minimal amounts of milk and meat, if plenty of wheat and vegetables are available."

8.9. More positive conclusions have been drawn by commentators. It has been claimed that, this experiment having failed to demonstrate any differences in nutritive value between the flours tested, it may now be assumed that the differences are negligible.

8.10. Other commentators have attributed the failure of the experiment to demonstrate any differences in nutritive value between the flours tested to alleged defects in the experiment. The chief criticisms are that the 70 per cent. extraction flour used was nutritionally superior to typical low extraction flour, that the responses to experiments on undernourished children are a poor guide to the effects on a more mature and better fed population, that the remainder of the diet was not readily comparable with a British diet and was too rich in vitamins for the experiment to have a chance to succeed, and that the experiment was not continued long enough. Evidence of depletion of vitamin reserves towards the end of the experiment has been cited.

8.11. The Panel has considered these criticisms. Having consulted the principals concerned in the experiment and the chief critics, the Panel has noted that the principals do not consider that their experiment provides a proven answer to the problems of the Panel although their opinions, based on their experience, would lead them to believe that the difference between unenriched low extraction flour and higher extraction flours is less than was anticipated at the time of the Conference on the Post-War Loaf and is probably small enough to be ignored in an otherwise well-balanced diet.

8.12. Although this investigation does not provide the answer to its specific problem, the Panel pays tribute to Professor McCance and Dr. Widdowson for this most valuable field experiment which has made a unique contribution to our knowledge of dietetic needs.

Section 9

DISCUSSION

9.1. The value of nutrients depends on the need for them. To assess their value it is necessary to know to what extent human beings are dependent on them and the quantities which are necessary for the maintenance of health. The findings of the British Medical Association([19]) have been accepted as an appropriate guide, but it is recognised that the allowances recommended are approximations only and that modifications may be made as knowledge increases.

9.2. The Reports of the National Food Survey([30]) and the Report of the Committee on Nutrition of the British Medical Association([19]) express their findings in statistical terms. They deal with average households, average families and average allowances. Those who are concerned with the standard of nutrition for the whole community will not be satisfied merely because on the average people are adequately fed but will wish to

ensure that, provided a surplus does no harm, the average intake will be so much greater than the average requirement that even the individuals whose intakes are most below the average still receive enough. Excess of calories, or excess of proteins, carbohydrates or fats should be avoided, but a moderate surplus of vitamins and other accessory food factors appears to have no ill effects. It is possible, however, for a gross excess of vitamins or of necessary trace elements to have ill effects and the indiscriminate and unrestrained fortification of foods is, therefore, undesirable.

9.3. When the choice of foods was narrower (for example, under war and post-war rationing) the range of individual intakes of nutrients was also narrower than it has been in recent years, when the public has had a wider choice of foods. So long as this widening of the range takes the form of an extension of the upper part of the range it would seem that no harm is done. If the lower limits fall there may be reason for disquiet. There is probably good cause to watch for a trend among the groups on the lowest nutritional planes to substitute foods rich in calories for protective foods. A fall in intake of vitamins of the B complex from bread might be of importance for these classes.

Protein

9.4. In the light of the deductions in paragraphs 6.11 and 6.12, the Panel does not feel that symptoms of malnutrition are likely to accompany the slight statistical deficiency in the total protein intake of children and adolescents (as compared with British Medical Association recommendations) indicated in Table 4, nor do they believe that the protein situation will be appreciably affected by the substitution of a 70 per cent. for an 80 per cent. extraction flour.

Vitamin B_1

9.5. The intake of vitamin B_1 recommended by the British Medical Association (see Appendix 5) is about twice the minimum requirement. The factor of safety is not large, especially as bodily stores are small. The requirement increases with the amount of carbohydrate eaten, and bread, as a starchy food, should contribute to the diet not only sufficient vitamin B_1 for its own utilisation, but also enough to help substantially with the metabolism of "B_1-less" foods such as sucrose. Bread made from unenriched 70 per cent. extraction flour cannot do this.

Nicotinic Acid

9.6. Nicotinic acid can be provided in the diet and it can be made in the body from the amino-acid, tryptophan, so long as there is no pyridoxine deficiency. Much of the nicotinic acid present in cereals occurs in a bound form so that its availability is reduced. The proteins of flour, however, contribute useful amounts of tryptophan to the diet. These complications make it difficult in general to judge how far different foods share in meeting the need for nicotinic acid and in particular they blur the assessment of differences in nutritional value between flours of different extraction rates. The addition of available nicotinic acid to flour of low extraction rate may well, however, be a true enrichment rather than a simple restoration.

Riboflavin

9.7. Riboflavin is a vitamin for which estimates of requirements are well established. The uptake, however, is less satisfactory than that of any of the other vitamins covered by the 1953 Report of the National Food Survey([30]). For certain classes the supply appears to be marginal to requirements. The

contribution made by bread to the estimated need for riboflavin is small and a difference between flours of different extractions is not in this respect significant. The Government's plans to safeguard the uptake of riboflavin are linked to its policy for milk rather than to its policy for bread.

Pyridoxine, Pantothenic Acid, Biotin and Folic Acid

9.8. Both the Medical Research Council and the Government's scientific and medical advisers have strongly emphasized the importance of more recently discovered vitamins such as pyridoxine, pantothenic acid, biotin and folic acid. The quantitative evidence to support their claim is incomplete. Estimations have been made to demonstrate the amounts present in flour and these show that there is less in low extraction flours than in 80 per cent. extraction flour. Data have been published which enable an estimate to be made of the amounts of these vitamins in an average diet. It would appear from these calculations that 80 per cent. extraction flour would contribute an important proportion of the total intake but the methods at present available for use in the estimation of these vitamins and related products indicate that caution must be exercised before accepting the findings as being anything more than approximations.

9.9. The British Medical Association has not specified recommended allowances for pyridoxine, pantothenic acid, biotin or folic acid. There is no doubt that these factors are essential for man's wellbeing. Deficiency states in man have been reported for pyridoxine([32]), biotin([33]) and folic acid, but these are exceptional and there appears to be no evidence that, even when diets contain a high proportion of low extraction flour, the amount of these nutrient factors is inadequate. It has been suggested that such deficiencies may only manifest themselves as a result of imbalance with other vitamins, or during a period of abrupt change in the diet, and that when they have occurred they may well have been obscured by the more obvious signs of other deficiencies. It is argued to the contrary that the science of nutrition has advanced to the stage at which it is improbable that deficiencies in our diet of national importance have been overlooked, although our understanding may improve.

9.10. Although much is known, therefore, about the parts played by pyridoxine, pantothenic acid, biotin and folic acid in the body, good estimates of dietary requirements have not been made. It has not been shown that the differences between flours of 70 per cent. extraction and 80 per cent. extraction in respect of these vitamins are significant to human nutrition.

Iron

9.11. Iron is one of the essential nutrients which is most likely to be deficient in the diet of industrial communities and a number of surveys before and during the last war showed that anaemia of the iron-deficiency type occurred frequently. Anaemia is particularly likely to occur in growing children, in women during the reproductive period, and in old age. Bread accounts for up to one-third of the total intake of iron. Although flour of higher extraction rates contains more iron than flour of lower extraction rates this is counterbalanced by the higher content of phytic acid, which interferes with the absorption of iron from the intestine. On the other hand, inorganic iron which is added to flour of lower extraction rate for the purposes of enrichment is adequately absorbed.

General

9.12. As a means of distinguishing between the nutritional values of flours of different extraction rates the results of the experiment by Professor McCance

and Dr. Widdowson in Germany were essentially negative. However, in Newfoundland in 1948([35]) it was found that the reinforcement of 70 to 72 per cent. extraction wheat flour with vitamin B_1, nicotinic acid, riboflavin, and iron, and of margarine with vitamin A, was followed by a marked improvement in the nutritional status of the population. Clinical signs of certain vitamin deficiencies which had been observed in 1944 had largely disappeared after four years of this enrichment policy. There were other contributory factors but the change in the flour was undoubtedly the most important. In Newfoundland the rest of the diet contained less vegetables than the rest of the diet in the German experiment and hence the benefit from the added nutrients was discernible. The pre-experimental Newfoundland diet had been inadequate in quality, while the German diet before the experiment had only been inadequate in quantity. Even the Newfoundland diet, however, does not appear to have been markedly deficient in pyridoxine, pantothenic acid, biotin or folic acid.

9.13. When the consumer has free choice of food the tendency is to choose the most attractive rather than the most nutritious. Bakers, competing for the public's custom, are in a position to ascertain what the people, as a whole, prefer. The whiteness and acceptable appearance of bread, which are in their judgment at least as good selling points as its taste, are better in the bread made from the lower extraction flours. It is not possible, however, to test this now because the public has to choose between an unsubsidised loaf, costing 10½d. to 1s. 0d. per 1¾ lb., made from enriched 70 per cent. extraction flour, and a subsidised loaf, costing 7½d. per 1¾ lb.,* made from a National flour whose extraction rate may not be higher than 74 per cent. (or its equivalent). There is very little difference in colour between 70 per cent. and 74 per cent. extraction flours. White flour is preferred by the manufacturers of cakes and biscuits in a competitive export market.

9.14. The Conference on the Post-War Loaf had sound grounds for believing that on average an 80 per cent. flour milled from the wheat at that time available would contain very nearly the proportions of nutrients which they specified. The eighth Report of the Scientific Adviser's Division of the Ministry of Food([21]) gave details based on the examination of over 4,000 samples of National 80 per cent. flour. The tests indicated, however, that even under control about 20 per cent. of the samples gave results 10 per cent. or more below the average for vitamin B_1. It is not possible for an independent analyst to prove that such a discrepancy in an individual sample is due to causes within the miller's control.

9.15. The composition of flour in terms of its content of " token " nutrients is not easy for the miller to ascertain as a day-to-day guide for his milling procedure. The necessary analyses take time, require extensive laboratory equipment, and skilled men are needed to perform them. The necessary facilities do not exist. Consultants provide general advice but not daily control of production in the mill. It would therefore be impracticable to enforce a nutritional standard for unenriched flour without providing for a wide range of variation. When wheat is milled to a low extraction, however, much of the variability in vitamin content disappears and it is possible with an unvarying addition of the " token " nutrients to ensure that a required minimum is reached. Difficulties are still experienced in securing uniformity in mixing, so that there will still be a variation in the analytical results, but American authorities have not found it impracticable under their system of administration to enforce their programme of enrichment of flour and bread.

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* At date of submission of this Report to Ministers.

9.16. The cost of added nutrients is relatively small. If the miller is free to sell enriched white flour of any technical quality which he desires there would not appear to be much temptation to add less than the specified quantities of nutrients. Experience has shown that the enrichment of low extraction flour on the average has been adequately carried out, but that more uniform mixing may be desirable.

Section 10

CONCLUSIONS

10.1. Flour, or the bread made from it, contributes nearly a third of the total calories and protein of the average British diet; it is, therefore, important that the flour should be as nutritious as possible. True 80 per cent. extraction flour will vary slightly in composition, which is partly dependent on the source, variety, shape, conditions of growth, moisture content and admixture with dirt, etc. of the grain used. The resources and skill of the miller can also affect flour composition. But, in general, a true 80 per cent. extraction flour will contain, as compared with flour of a lower extraction rate,* :—

(*a*) more of certain essential nutrients, such as protein, vitamin B_1, nicotinic acid and iron, of which a lack produces well known deficiency states in man;

(*b*) more of the other essential nutrients such as pyridoxine, pantothenic acid, biotin and folic acid, of which evidences of deficiency in man have very rarely been recorded;

(*c*) a little more riboflavin, an essential vitamin but one which is mainly supplied by other foods such as milk and eggs.

10.2. It is, however, a simple process to add vitamin B_1, nicotinic acid and iron to lower extraction flours so that the contents of these nutrients amount to or exceed those in 80 per cent. extraction flour, without impairment of technical quality. By so doing, the intake of these nutrients can be made rather more stable than it is when they are supplied by 80 per cent. extraction flour because of the unavoidable variations in nutrient content of such flour.

10.3. The Panel's main problem has been to decide to what extent the remaining differences are significant. The history of nutrition reveals many instances where the refinement or over-purification of food has led to ill-health and there is no reason to believe that this chapter of knowledge is closed. It is also true that popular choice of foods has often proved misguided.

10.4. Differences in the nutritive value of flours can be corrected by the adequacy of the rest of the diet. Nevertheless, there is a significant fraction of the British population in which the rest of the diet may not supply certain essential nutrients in sufficient amounts, owing partly to limited income, partly to inadequate knowledge of dietetics and partly to the attraction of foods which are poor in these essential nutrients. The Panel is particularly impressed by the fact that 10 per cent. of British children may pass their childhood in such circumstances. *The Panel is of the opinion that nutrition in such individuals would fall below the level necessary for good health if there were a return to the pre-war practice of making bread from flour*

* The Panel has taken 70 per cent. extraction as a reference point among lower extraction flours (see paragraph 6.6.)

of extraction rates of 70 to 72 per cent. to which vitamin B_1, nicotinic acid and iron had not been restored.

10.5. Although there is some evidence that the quality of the protein of 70 per cent. extraction flour is less than that of 80 per cent. extraction flour, *the Panel is of opinion that when 70 per cent. extraction flour is blended with the remainder of the diet its use is most unlikely to give rise to symptoms of protein malnutrition.*

10.6. Human requirements of pyridoxine, pantothenic acid, biotin and folic acid are not known and information as to their distribution in foods and flours of various grades is far from complete. *The Panel's review of the relevant literature leads them to believe that, in spite of weighty opinion to the contrary, a lowering of the extraction rate from 80 per cent. to 70 per cent. is very unlikely to lead to any nutritional disturbance from lack of these vitamins.*

10.7. Bread made from either 80 per cent. extraction or 70 per cent. extraction enriched flour is an excellent food. A true 80 per cent. extraction flour may give a more widely spread insurance against possible, but as yet unproved, deficiency in the rest of the diet; the 70 per cent. enriched flour gives a more *certain* cover against possible deficiency of the three "token" nutrients with well recognised deficiency states. There is not a great deal to choose here. Enrichment with other essential nutrients is outside our Terms of Reference.

10.8. The Panel is impressed by the evidence for the demand for white flour and white bread. The professional pride of the miller in producing as clean and white a flour as possible is one reason for this preference for white flour, though the miller is also, naturally, concerned to gain the highest possible yield of flour from the grain. A further influence is the preference of the bakers for low extraction flour, which they find easier to handle and from which they can produce more appetising bread, rolls, cakes and biscuits. Finally, the public prefer bread and cake made with the whiter kinds of flour. The Panel believes that the pressure for a flour whiter than a true 80 per cent. extraction flour is strong and it is this which has led to the acknowledged infringement of the spirit of the Flour Order, 1953([12]). There is a risk, the industry claim, that if people can obtain only bread made from 80 per cent. extraction flour they may eat less bread and more of other manufactured foods which may not be so nourishing.

10.9. It is acknowledged by all expert witnesses that, with current milling methods, it is difficult to enforce a fixed extraction rate and that the composition of flour is not an accurate measure of its extraction rate. When two or more types of flour are being produced simultaneously they cannot be described and compared accurately in terms of extraction rates.

10.10. The Panel believes that experience has demonstrated fundamental difficulties in operating the present system of differentiation between flours for subsidy purposes, and that a policy of enrichment provides a realistic means of ensuring that the greatest nutritional benefit is derived from flour. Flours of higher extraction rate, containing no less nutrients than the enriched low extraction flours, should also be available.

10.11. *Taking into account all the circumstances, and bearing in mind particularly the needs of the vulnerable groups in the population, the Panel concludes that the available evidence does not reveal any ascertainable difference between National flour as defined in the Flour Order, 1953, and*

flours of extraction rate less than National flour, to which vitamin B_1, nicotinic acid and iron have been restored in the amounts specified in the Flour Order, 1953, *which would significantly affect the health of the population in any foreseeable circumstances. They believe, however, that differences between low extraction flour enriched as specified and low extraction flour not so enriched are significant.*

10.12. The conclusions reached by the Panel differ from those presented in their evidence by the Government's medical and scientific advisers and by the Medical Research Council. These advisers have been admirably zealous and eminently successful in guarding the nutritional well-being of all sections of the population and their scientific arguments have not been disproved. The National Food Survey, by providing the necessary data and a proper perspective, should continue to be of great assistance in the periodic review, in the light of advancing knowledge, of policy concerning bread.

HENRY COHEN (*Chairman*).

A. C. CHIBNALL.

J. H. GADDUM.

R. A. MORTON.

L. J. WITTS.

K. B. W. JONES (*Technical Secretary*).

BARBARA M. SHEDDEN (*Secretary*).

10*th January,* 1956.

APPENDIX 1

HOUSEHOLD CONSUMPTION OF NATIONAL* AND WHITE BREAD, EXCLUDING CONSUMPTION IN THE HOUSEHOLD OF WHOLEMEAL BREAD, MALT BREAD, ROLLS AND SPECIALITY BREADS

	Ounces per head per week			Proportions of consumption of National and White Bread	
	(1) National	(2) White	(3) Total	(4) National	(5) White
1953—September ...	47·55	2·21	49·76	95·6	4·4
October ...	48·20	1·36	49·56	97·3	2·7
November ...	47·76	1·15	48·91	97·6	2·4
December ...	47·91	1·00	48·91	98·0	2·0
4th quarter (average)	47·96	1·17	49·13	97·6	2·4
1954—1st quarter ...	50·89	0·81	51·70	98·4	1·6
2nd quarter ...	51·16	0·67	51·83	98·7	1·3
3rd quarter ...	51·25	0·69	51·94	98·7	1·3
4th quarter ...	51·42	0·36	51·78	99·3	0·7
1955—1st quarter ...	50·42	0·56	50·98	98·9	1·1
2nd quarter ...	50·41	0·40	50·81	99·2	0·8
3rd quarter ...	51·39	0·40	51·79	99·2	0·8

* Under the Flour and Bread Orders, 1953, provision is made for the production of National *brown* flours and corresponding National *brown* breads. National *brown* flours are flours of an extraction rate *exceeding* 80 per cent. The consumption figures for National *brown* breads have been included in this Table ; they run at a roughly constant level of about 2 ozs. per head per week.

(Source: Reports of the National Food Survey Committee).

APPENDIX 2

Composition of Bulked Samples of Flour from Mills of Graded Capacity in the Year 1954

	Recommended level	National Straight-run	National by Divides	Enriched 70 per cent. Extraction
Vitamin B_1 (mg/100 g.)	0·24	0·19—0·21	0·19—0·20	0·25—0·32
Nicotinic Acid (mg/100 g.) ...	1·60	1·42—1·50	1·53—1·58	1·58—1·88
Riboflavin (mg/100 g.)	—	0·05	0·05	0·03—0·04
Iron (mg/100 g.)	1·65	1·5—1·6	1·5	1·6—1·8
Number of samples* included in the bulk analysed	—	2,213	1,496	4,758
Grade colour—				
January	—	4·1—4·9	3·8—4·4	1·9—4·1
December	—	2·9—4·0	2·9—3·5	2·9—3·6

Composition of Bulked Samples of Flour from Mills of Graded Capacity, for the period January–March, 1955†

	Recommended level	National Straight-run	National by Divides	Enriched 70 per cent. Extraction
Vitamin B_1 (mg/100 g.)	0·24	0·18—0·21	0·18—0·21	0·23—0·27
Nicotinic Acid (mg/100 g.) ...	1·60	1·4—1·6	1·5—1·7	1·6—1·8
Riboflavin (mg/100 g.)	—	0·04—0·05	0·05	0·04
Iron (mg/100 g.)	1·65	1·6—1·8	1·5—1·7	1·3—1·7
Number of samples* included in the bulk analysed	—	629	346	1,190

(Source: Report of the Government Chemist for the year ending 31st March, 1955 ([36]), and unpublished data from the Department of the Government Chemist).

* Individual samples of each type of flour collected from mills during each month are bulked into five groups according to the milling capacity of the mills concerned. These bulk samples are then analysed. The above Tables show the range of results of these analyses.

† During 1955 an increasing number of National flours showed signs of added vitamin B_1. Hence it is not possible to deduce the extraction rate from the results of assays for " token " nutrients. The grade colour figures quoted for 1954 illustrate the trend towards lower extraction during the year.

APPENDIX 3

COMPOSITION OF FLOUR OF VARIOUS EXTRACTION RATES (PER 100 G.)

	Patent Flour (about 50 per cent. Extraction)	Straight-run (about 72 per cent. Extraction)	80 per cent. Extraction including $10\frac{1}{2}$ oz. creta praeparata per sack of 280 lbs.	Wholemeal (95 to 100 per cent. Extraction)
Protein (g.)	10·0	11·0	11·4	12·0
Vitamin B_1 (mg.)... ...	0·08	0·11	0·26	0·40
Nicotinic Acid (mg.) ...	0·70	0·72	1·20	6·0
Riboflavin (mg.)	0·03	0·035	0·05	0·12
Pyridoxine (mg.)	0·1	0·15	0·25	0·5
Pantothenic Acid (mg.) ...	0·4	0·6	0·9	1·5
Biotin (mg.)	0·0005	—	—	0·0007
Calcium (available) (mg.)	15·0	18·0	57·0	Negative
Iron (available) (mg.) ...	0·9	1·0	1·8	2·7 (?)

(Source: Cantor Lecture by Dr. D. W. Kent-Jones, Ph.D., B.Sc., F.R.I.C. Journal of the Royal Society of Arts, Vol. XCVIII, 13th January, 1950)

APPENDIX 4

LEVELS OF VITAMIN B_1 IN FLOUR OF 70–72 PER CENT. EXTRACTION

Source	Date	Vitamin B_1 content (mg/100 gms. flour)
Cantor Lecture given by Dr. D. W. Kent-Jones, Ph.D., B.Sc., F.R.I.C., before the Royal Society of Arts[16] ...	December, 1949	0·11
Memorandum of Evidence to the Panel from the Medical and Scientific Advisers of the Ministry of Health, the Ministry of Agriculture, Fisheries and Food and the Department of Health for Scotland	August, 1955	0·08
Ministry of Food Manual of Nutrition	1945	0·07
Ministry of Food	February, 1953	0·08
McCance, R. A., Widdowson, E. M., Moran, T., Pringle, W. J. S. and Macrae, T. A. Biochem. J., 1945, *39*, 213:—		
All Manitoba wheat grist	1945	0·066
All English wheat grist	1945	0·084
70 per cent. extraction flours unenriched used by Professor R. A. McCance and Dr. E. M. Widdowson in Germany[10]	1947/48	0·11–0·16

APPENDIX 5

COMPARISON OF RECOMMENDATIONS MADE IN THE UNITED STATES OF AMERICA, CANADA AND THE UNITED KINGDOM FOR DAILY NUTRIENT INTAKES AFTER SUITABLE ADJUSTMENT FOR ACCORD WITH UNITED KINGDOM STATISTICS FOR POPULATION CHARACTERISTICS OF AGE, SEX AND WEIGHT

	National Research Council (U.S.A.)	Canadian Council on Nutrition	British Medical Association
Basis of Recommendation	Maintenance of good nutrition of the majority	Minimum safe nutritional floor	Good nutritional state of representative individuals
Energy value (cal.)	2,434	2,442	2,564
Protein (g)	61	55	80*
Calcium (g)	0·9	0·7	0·9
Iron (mg)	12	9	12
Vitamin B_1 (mg)	1·2	0·7	1·0
Riboflavin (mg)	1·5	1·2	1·5
Nicotinic Acid (mg) ...	12	7	10

* The weighted requirements per head of the population published in the Report of the Committee on Nutrition of the British Medical Association([19]) were based on the United Kingdom 1948 population, but were incorrect in one respect: the protein requirements should have been 79 and not 71.

The weighted estimates given in this Appendix have been recalculated for the United Kingdom 1955 population, and are slightly higher for both calories and protein than previously.

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